

We claim as our invention:

Sub A1 1. A method for training a system to inspect a spatially distorted pattern, the method comprising:

receiving a digitized image of an object, the digitized image including a region of interest;

dividing the region of interest into a plurality of sub-regions, a size of each of the sub-regions being small enough such that a conventional inspecting method can reliably inspect each of the sub-regions;

training a search tool and an inspection tool for a respective model for each of the plurality of sub-regions;

building a search tree for determining an order for inspecting the plurality of sub-regions at a run-time; and

training coarse alignment tool for the region of interest.

Sub B1 2. The method according to claim 1, wherein the size of each of the sub-regions is small enough such that each of the sub-regions is well approximated by an affine transformation.

3. The method of claim 1, wherein the building of the search tree comprises: establishing the order so that transformation information for located ones of the sub-regions is used to minimize a search range for neighboring ones of the sub-regions.

4. The method of claim 1, wherein the training of the search tool for the respective model for each of the plurality of sub-regions is performed by using a correlation search.

5. The method of claim 1, wherein the training of the inspection tool for the respective model for each of the plurality of sub-regions is performed by using a golden template comparison method.

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6. A method for inspecting a spatially distorted pattern, the method comprising:
running a coarse alignment tool to approximately locate the pattern;
using search tree information and an approximate location of a root sub-region, found by the coarse alignment tool, to locate a plurality of sub-regions sequentially in an order according to the search tree information, each of the sub-regions being of a size small enough such that a conventional inspecting method can reliably inspect each of the sub-regions; and inspecting each of the sub-regions.

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7. The method of claim 6, further comprising:
combining all location information to produce a distortion vector field for each of the sub-regions; and
using the distortion vector fields to make a pass/fail decision based on user-specified tolerances.

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8. The method of claim 6, wherein:
the inspecting produces a difference image for each of the sub-regions and a match image for each of the sub-regions, the method further comprising:
combining the difference images for each of the sub-regions into a single difference image; and
combining the match images for each of the sub-regions into a single match image.

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9. The method of claim 7, wherein:

the inspecting produces a difference image for each of the sub-regions and a match image for each of the sub-regions, the method further comprising:

combining the difference images for each of the sub-regions into a single difference image;

combining the match images for each of the sub-regions into a single match image;

and

combining all location information to produce a distortion vector field for each of the sub-regions.

10. The method according to claim 6, wherein the size of each of the sub-regions is small enough such that each of the sub-regions is well approximated by an affine transformation.

11. The method of claim 6, further comprising:

using transformation information from located ones of the sub-regions to interpolate transformation information for a sub-region when the sub-region cannot be located; and inspecting the sub-region based on the interpolated transformation information.

12. The method of claim 6, further comprising:

using the respective models for at least some of the sub-regions to determine respective transformation information; and predicting registration results in at least one of the sub-regions by using the respective transformation information of neighboring ones of the at least some of the sub-regions when

training of the search tool for the respective model for the at least one of the sub-regions was not successfully performed.

13. The method of claim 6, wherein the inspecting of each of the sub-regions is performed by a golden-template comparison method.

sub A 14. An apparatus for inspecting a spatially distorted pattern, the apparatus comprising:

a memory for storing a digitized image of an object;
a region divider for dividing the digitized image of a region of interest into a plurality of sub-regions, a size of each of the sub-regions being small enough such that a conventional inspecting method can reliably inspect each of the sub-regions;
a coarse alignment mechanism for approximately locating the pattern;
a search mechanism for locating each of the sub-regions sequentially in an order based on search tree information; and
an inspector for inspecting each of the sub-regions.

sub B 15. The apparatus of claim 14, further comprising:

a vector field producer to combine all location information to produce a distortion vector field for each of the sub-regions; and
a comparing mechanism for using the distortion vector field to make a pass/fail decision based on user specified tolerances.

16. The apparatus of claim 14, wherein:

the inspector for inspecting each of the sub-regions produces a difference image for each of the sub-regions and a match image for each of the sub-regions, the apparatus further comprises:

a first combiner for combining the difference images for each of the sub-regions into a single difference image; and

a second combiner for combining the match images for each of the sub-regions into a single match image.

17. The apparatus according to claim 14, wherein the size of each of the sub-regions is small enough such that each of the sub-regions is well approximated by an affine transformation.

18. The apparatus of claim 14, further comprising:

an interpolator for using transformation information from located ones of the sub-regions to interpolate transformation information for a sub-region when the sub-region cannot be located by the search mechanism, wherein

the inspector inspects the sub-region based on the interpolated transformation information.

19. The apparatus of claim 14, further comprising:

an interpolator for using the respective models for at least some of the sub-regions to determine respective transformation information, and for predicting registration results in at least one of the sub-regions by using the respective transformation information of neighboring ones of the at least some of the sub-regions when training of the respective model for the at least one of the sub-regions was not successfully performed.

20. The apparatus of claim 14, wherein the inspector inspects each of the sub-regions by using a golden-template comparison method.

21. An apparatus for inspect a spatially distorted pattern, the apparatus comprising:
a storage for storing a digitized image of an object, the digitized image including a region of interest;

a region divider for dividing the region of interest into a plurality of sub-regions, a size of each of the sub-regions being small enough such that a conventional inspecting method can reliably inspect each of the sub-regions;

a trainer for training a respective model for a search tool and for an inspection tool for each of the plurality of sub-regions;

a search tree builder for building a search tree for determining an order for inspecting the plurality of sub-regions at a run-time;

a coarse alignment trainer;

a coarse alignment mechanism for approximately locating the pattern, the coarse alignment mechanism being configured to be trained by the coarse alignment trainer;

a search mechanism for locating each of the sub-regions sequentially in an order based on the search tree, a root sub-region being provided by the coarse alignment mechanism; and an inspector for inspecting each of the sub-regions.

22. The apparatus according to claim 21, further comprising:

a vector field producer to combine all location information to produce a distortion vector field for each of the sub-regions; and

a comparing mechanism for using the distortion vector fields to make a pass/fail decision based on user specified tolerances.

23. The apparatus of claim 21, wherein:

the inspector produces a difference image for each of the sub-regions and a match image for each of the sub-regions, the apparatus further comprises:

a first combiner for combining the difference images for each of the sub-regions into a single difference image; and

a second combiner for combining the match images for each of the sub-regions into a single match image.

24. The apparatus according to claim 21, wherein the size of each of the sub-regions is small enough such that each of the sub-regions is well approximated by an affine transformation.

25. The method of claim 21, wherein the building of the search tree comprises: establishing the order so that transformation information for located ones of the sub-regions is used to minimize a search range for neighboring ones of the sub-regions.

26. The apparatus of claim 21, further comprising:

an interpolator for using transformation information from located ones of the sub-regions to interpolate transformation information for a sub-region when the sub-region cannot be located, wherein

the inspector inspects the previously unlocated sub-region based on the interpolated transformation information.

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27. A medium having stored therein machine-readable information, such that when the machine-readable information is read into a memory of a computer and executed, the machine-readable information causes the computer:

- to receive a digitized image of an object, the digitized image including a region of interest;
- to divide the region of interest into a plurality of sub-regions, a size of each of the sub-regions being small enough such that a conventional inspecting method can reliably inspect each of the sub-regions;
- to train a respective model for a search tool and for an inspection tool for each of the plurality of sub-regions;
- to build a search tree for determining an order for inspecting the plurality of sub-regions at a run-time; and
- to train a respective model for a coarse alignment tool.

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28. The medium of claim 27, wherein when building the search tree, the machine-readable information causes the computer:

- to establish the order so that transformation information for located ones of the sub-regions is used to minimize a search range for neighboring ones of the sub-regions.

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29. The medium of claim 27, wherein the machine-readable information further causes the computer:

- to run a coarse alignment tool to approximately locate a pattern;
- to use information from a search tree and a root sub-region approximately located by the coarse alignment to locate a plurality of sub-regions sequentially in an order according to

the information from the search tree, each of the sub-regions being of a size small enough such that a conventional inspecting method can reliably inspect each of the sub-regions; and to inspect each of the sub-regions to produce a difference image for each of the sub-regions and a match image for each of the sub-regions.

30. The medium of claim 29, wherein the machine-readable information further causes the computer:

to combine the difference images for each of the sub-regions into a single difference image; and

to combine the match images for each of the sub-regions into a single match image.

31. The medium of claim 29, wherein the machine-readable information further causes the computer:

to combine all location information to produce a distortion vector field for each of the sub-regions; and

to use the distortion vector fields to make a pass/fail decision based on user-specified tolerances.

32. The medium of claim 27, wherein the machine-readable information further causes the computer:

to use transformation information from located ones of the sub-regions to interpolate transformation information for a sub-region when the sub-region cannot be located; and

to run a search tool on the sub-region based on the interpolated transformation information.

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33. The method of claim 6, further comprising:

dividing one of the sub-regions into a plurality of smaller sub-regions when the one of the sub-regions cannot be located during the using of the search tree information to locate the plurality of sub-regions.

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34. A method for inspecting a spatially distorted pattern, the method comprising:

running a coarse alignment tool to approximately locate the pattern;

using search tree information and an approximate location of a root sub-region, found by the coarse alignment tool, to locate a plurality of sub-regions sequentially in an order according to the search tree information, each of the sub-regions being of a size small enough such that a conventional inspecting method can reliably inspect each of the sub-regions;

combining all location information to produce a distortion vector field for each of the sub-regions; and

using the distortion vector fields to make a pass/fail decision based on user-specified tolerances.

35. An apparatus for inspecting a spatially distorted pattern, the apparatus comprising:

a memory for storing a digitized image of an object;

a region divider for dividing the digitized image of a region of interest into a plurality of sub-regions, a size of each of the sub-regions being small enough such that a conventional inspecting method can reliably inspect each of the sub-regions;

a coarse alignment mechanism for approximately locating the pattern;

a search mechanism for locating each of the sub-regions sequentially in an order based on search tree information;

a vector field producer to combine all location information to produce a distortion vector field for each of the sub-regions; and

a comparing mechanism for using the distortion vector field to make a pass/fail decision based on user specified tolerances.

36. A medium having stored therein machine-readable information, such that when the machine-readable information is read into a memory of a computer and executed, the machine-readable information causes the computer:

to run a coarse alignment tool to approximately locate a pattern;

to use information from a search tree and a root sub-region approximately located by the coarse alignment to locate a plurality of sub-regions sequentially in an order according to the information from the search tree, each of the sub-regions being of a size small enough such that a conventional inspecting method can reliably inspect each of the sub-regions;

to combine all location information to produce a distortion vector field for each of the sub-regions; and

to use the distortion vector fields to make a pass/fail decision based on user-specified tolerances.